## A STUDY OF WELL CONSTRUCTION FOR ARSENIC CONTAMINATION IN NORTHEAST WISCONSIN

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Arsenic has been detected in approximately one third of the private drinking water wells in the Fox River valley of Northeast Wisconsin. Concentrations detected are some of the highest found naturally occurring in the world. Research has indicated that presently 3.5% of the wells in Outagamie and Winnebago counties exceed the current drinking water standard of 50 ppb.

Department of Natural Resources study results indicate the geochemical phenomenon causing the elevated levels of arsenic in groundwater of this region is associated with oxidation of a sulfide-mineralized zone located at the top of the deep sandstone aquifer system. A regional decline in water levels may have exposed this sulfide rich zone to oxidation from air within the open boreholes of water wells extending through this zone. This oxidation process can initiate a chemical reaction similar to acid mine drainage.

Recommendations have been developed for constructing wells within a delineated advisory area. This guidance recommends constructing wells with well casing pipe to extend through the sulfide rich zone. This study compared arsenic concentrations of wells constructed according to the guidance, with wells constructed to traditional construction standards. Additionally, this study examined data to determine if it was better to replace a contaminated well with a new one, or to reconstruct the existing well with a liner.

The results of this study indicate that the guidance gives adequate protection for wells constructed in the arsenic advisory area and that liners are successful at reducing arsenic concentrations, although not as successful eliminating arsenic contamination.

## Geology

Quarternary Deposits – Predominantly fine grained tills and lacustrine silts and clays. Minor amounts of sand and gravel deposits are present throughout the area.

Sinnipee Group – Dolomite with a thin shale formation in the middle. The Galena- Platteville formations are massive and regionally acts as an aquitard , yet are good for domestic supply where weathered and fractured.

Ancell Group – St. Peter formation is a fine to medium grained sandstone with a thin silty sandstone formation on top and shale at the base. Thickness is variable in the area.

Prairie du Chien Group – Dolomite with varying amounts of oolitic chert. Thin or absent where the St. Peter is very thick.

Jordan Formation – Fine to medium grained sandstone.

Tunnel City Group - Fine to medium grained sandstone, silty sandstone and glauconitic dolomite.

Elk Mound Group – Very fine to fine grained sandstone and medium to course grained sandstone.

Precambrian – Granitic rocks, undifferentiated.

1 The original well on this property was constructed in 1978. It was 6" hole with casing to 44 feet and a total depth of 123 feet. In 1994 the well was sampled and had an arsenic level of 987 ppb. A new well was constructed to the recommended specifications. A 9" hole was drilled to 151 feet. Six-inch casing was installed

to 152 feet. The total depth of the new well was 180 feet. In 1999 declining water quality lead to further investigation. Arsenic levels had again risen to the 1000 ppb level. It is suspected that problems with caving sandstone during the grouting process may have allowed the aggressive water to corrode the casing and contaminate the well. This same problem has been documented at a nearby well. A new 303-foot well with 250 feet of casing has been constructed on the property and has been fine so far.

**2** This well was constructed in 1977, with 6" casing to 44' and a total depth of 123'. The contact between the Galena-Platteville dolomite and the St. Peter Sandstone was reported at 75'. In 1978 a packer was installed at 87' to reduce high iron. In 1990 the homeowners reported the water from this well to be an irritant to their skin, have a metallic taste and were deteriorating the plumbing fixtures. The DNR was contacted in 1991 and found that the water had a pH of 2.5 Sample results from 1992 were:

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pH = 2.05
As = 4300+ ppb
Cr = 84 ppb
Cd = 220 ppb
Ni = 11000 ppb
Al = 15000 ppb
Co = 5500 ppb
Pb = 400 ppb
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A new well was installed in 1993 as a shallow dolomite well with a total depth of 40'. The well continues to produce treatable potable water.

Sample results from that well in 1995 were:

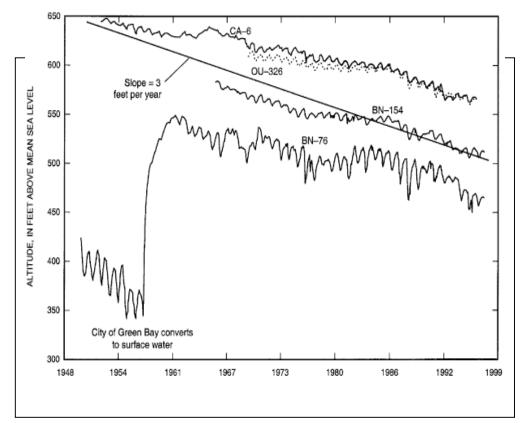
pH = 7.08 As = 5 ppb Ni = 8 ppbPb = ND

**3** This well was constructed 1/92 to a total depth of 155' with casing set to 45'. The static water level was 70', which dropped to 94' while pumping. Normal pumping caused the water level to fluctuate across the contact of the Galena-Platteville dolomite and St Peter sandstone, the most concentrated zone of sulfide mineralization. 10/19/93 sample results

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pH= 6.4
As = 12,000 ppb
11/17/93
As = 15,000 ppb
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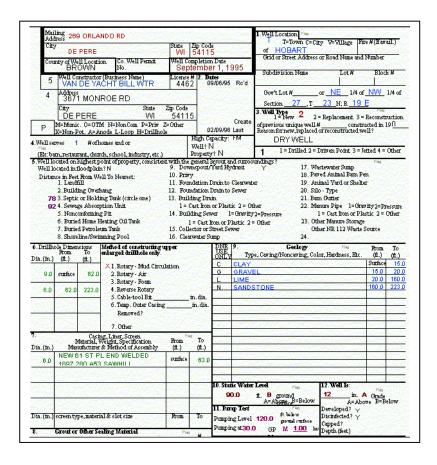
This well and a neighboring well were reconstructed by drilling deeper, into Cambrian sandstone and grouting in a 4" liner to 290'. Since then all arsenic results have been <5 ppb in one well and range from 1.2 to 6.6 in the other well. Another well right next door was drilled out to 243 feet and a 4" liner was grouted to 153'. Arsenic concentrations in the reconstructed well dropped to 18 ppb, but have been rising and are now in the 200 ppb range.

**4** Oxidation of the sulfide minerals is being enhanced due to a large cone of depression caused by Municipal and Industrial pumping in the Green Bay area. As can be seen on this hydrograph, after an



initial rebound in 1957 when Green Bay switched to surface water for a municipal supply, the water levels have been declining at a rate of about 3 feet per year.

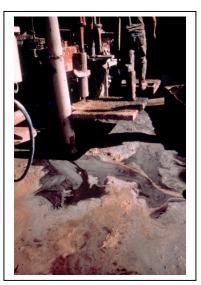
Land-use activities and development of high density housing (sub-divisions) have locally reduced infiltration along with higher water demands have also contributed to declining water levels. As can be seen on the attached well construction reports, two wells were replaced in 1995 for lack of water. The wells developed a problem with arsenic, with reported levels over 900 ppb. The construction reports for the new wells on the same properties indicate static water levels are 30 to 40 feet lower in 1998 than in 1995.



|  |  |  |  | State<br>VVI   | State Zip Code<br>VVI 54115                                 |   |   |  | T=Town C=City V=Village Fire#(ffawail.) of HOGAR                                     |                     |   |  |   |   |                          |
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| County of Well Location   Co. Well Permit   W  |  |  |  | Well<br>Sep  | Vell Completion Date<br>September 23, 1998                  |   |   | Grid or Street Address or Road Name and Number 269 ORLANDO DR Subdivision Name Lot# Block# |  |                     |   |  |   |   |                          |
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|  |                      |                    |               |                    |          |                              | 23. Ot              | her Marc     | um Storag            |                   |                    |
| 7. Buried Petroleum, Tank  | 15.C∘ <b>I</b> i     | atozoz 8           | tmet Se       | Plastic 2 :<br>Wex |          |                              | Ot                  | her NR.1     | 12 Waste             | Sounce            |                    |
|  |                      | rwahi S            |               |                    |          |                              | 24.                 |              |                      |                   |                    |
| L Dimersions Method of constructing up   | nar.                 |                    | DINK.         | 19.                |          | Char                         | ber                 | Fb           |                      | From              | Ιο                 |
| PTOTA IO  enkarged drillhole only. `   | rpo.                 |                    |               |                    | no Carri |                              |                     |              | iness, Etc.          | (ft.)             | ( <del>ft</del> .) |
| (ft.) (ft.)  |                      |                    | C             | CLAY               |          |                              |                     |              |                      | Surfac            | · · · · ·          |
| 1. Botary - Mud Cincul   | ation.               |                    | -             | LIMES              |          |                              |                     |              |                      | 4                 | 42                 |
| ruufasa 83 X 2. Botany - Air   |                      |                    | KN            |                    |          | IDSTON                       | <u></u>             |              |                      | 42                |                    |
| 3. Rotary - Foam   |                      |                    | GN            |                    |          | DSTON                        |                     |              |                      | 61                | - n<br>82          |
| 83 100 + Raverse Rotary  |                      |                    | IN            |                    |          | DSTON                        |                     |              |                      | 82                | 100                |
| 5.Cable-toolBit  |                      | a dia.             | IIN           | VVIIII             | E SHIY   | IDSTOR                       | 1=                  |              |                      | 02                |                    |
| f. Ismp. OutsrCasing   |                      | _in.dis.           |               | _                  |          |                              |                     |              |                      |                   |                    |
| Ramoued?   |                      |                    | _             | _                  |          |                              |                     |              |                      |                   |                    |
| 1 204  |                      |                    |               | -                  |          |                              |                     |              |                      |                   |                    |
| 7.Ofter  |                      |                    |               |                    |          |                              |                     |              |                      |                   |                    |
| Caring Lines Screen<br>Material Weight Specification   | From                 | To.                |               |                    |          |                              |                     |              |                      |                   |                    |
| Manufactum: & Mathod of Assembly   | ( <del>ft.</del> )   | ( <del>ft</del> .) |               |                    |          |                              |                     |              |                      |                   |                    |
| NEW BLACK STEEL, P.E.,   |                      | 12117              |               |                    |          |                              |                     |              |                      |                   |                    |
| TAMAN PIPE ASTM  | entre e              | 83                 |               |                    |          |                              |                     |              |                      |                   |                    |
| Termiew PIPE STIM  | -                    |                    |               |                    |          |                              |                     |              |                      |                   |                    |
|  |                      |                    |               |                    |          |                              |                     |              |                      |                   | _                  |
|  |                      |                    | .0.Stet       | ic Weter           | r Level  |                              | _                   | 12. We       | ll L:                | -                 | _                  |
|  |                      |                    | 52.0          | 4                  | В        | ground                       | -                   | 1            | <u>12 in </u> A      |                   |                    |
|  |                      |                    |               |                    |          | bove B                       | =Belov              | л—           |                      | us B≕B            | ebw                |
|  |                      |                    | II. Pun       | np Test            |          |                              | Fbo                 |              | ped? Y               |                   |                    |
| omen type, material & slot size  | From                 | Īo                 |               | ngLaus             | 72.0     | ft. bak                      | w                   |              | chd? Y               |                   |                    |
|  | _                    |                    | _             |                    |          | goomé                        | Leggiage            | Саттей       | 12 V .               |                   |                    |
| *  |                      |                    | Pumpi         | ngat15.            | D GF     | MY.                          | $8.00  \mathrm{hm}$ | The wall     | شمه                  |                   |                    |

The Sulfide Cement Horizon (SCH) can sometimes be seen during the drilling of the well. Drillers often report it on Well Construction Reports (see example). The picture shows black sand and mud being returned with the cuttings and



sometimes an oily sheen can be present also. However, the black color is not always present or noticeable.

6 In a subdivision, just southwest of Green Bay, water levels had declined and all the wells in the area had arsenic in the 1000 ppb range. The pH in a number of the wells was around 3. Several of the wells produced acceptable water after being deepened and lowering the pump, but only for short periods of time. All of the homes are now served by municipal water.